**3 ● Using the data from Question 2, if city water costs 20 cents per thousand gallons, and if 1.25 gallons are used per minute per ton, estimate the annual water cost.**

$60 \times 1.25 = 75$ gal per ton-hour.
181,824 ton-hours $\times$ 75 = 13,620,000 gal per year.

$\frac{13{,}620{,}000 \times \$0.20}{1000} = \$2{,}724$ the yearly cooling water cost.

**4 ● Using the data of Question 2, if *a cooling tower were installed for re-using the condensing water, estimate the annual compressor power cost of a dichloro-difluoromethane refrigeration system if the final temperatures of the water leaving the cooling tower and the kilowatt input per ton are the following:***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tons | 284 | 233 | 183 | 157 | 144 | 79 | 37 |
| Temperature of water leaving tower, F | 86.7 | 81.8 | 76.5 | 72.1 | 66.4 | 61.3 | 55.6 |
| Kw input per ton | 1.10 | 0.94 | 0.85 | 0.80 | 0.74 | 0.59 | 0.62 |

| Wet-Bulb Temperature F | Ton-Hours | | Kw per Ton | | Kwhr |
|---|---|---|---|---|---|
| 80 | 1,704 | × | 1.10 | = | 1,875 |
| 79 – 75 | 23,300 | × | 0.94 | = | 21,900 |
| 74 – 70 | 50,700 | × | 0.85 | = | 43,300 |
| 69 – 65 | 51,800 | × | 0.80 | = | 41,400 |
| 64 – 60 | 39,900 | × | 0.74 | = | 29,500 |
| 59 – 55 | 12,500 | × | 0.59 | = | 7,370 |
| 54 – 50 | 1,920 | × | 0.62 | = | 1,200 |
| Totals | 181,824 ton-hours | | | | 146,545 kwhr |

The 146,545 kwhr at 2 cents per kwhr will cost \$2,931.

The average consumption will be $\frac{146{,}545 \text{ kwhr}}{181{,}824 \text{ ton-hours}} = 0.805$ kw per ton.

**5 ● If a steam ejector system were used to secure the refrigeration for the air conditioning system of Question 2, compute the annual steam cost if steam is sold for 53 cents per thousand pounds and if there is an average steam consumption of 20 lb of steam per hour per ton when used with a cooling tower system.**

181,824 tons $\times$ 20 lb of steam per ton = 3,636,480 lb of steam.
The 3,636,480 lb at 53 cents per thousand pounds will cost \$1,929.

**6 ● Discuss the difference in results obtained in cooling and dehumidifying in an air washer from those obtained in a surface cooling coil.**

Air leaves a dehumidifying air washer in a saturated condition at a dew point temperature which can be easily maintained at a constant level by controlling the spray water temperature. This saturated air may then be reheated to proper delivery temperature by reheating coils or by mixing with by-passed air.

For a set air velocity and a set mean refrigerant temperature, a given cooling coil is capable of absorbing a definite amount of heat. Whether the air leaving the coil is saturated or not depends then on the entering dry- and wet-bulb temperatures. From practical operating standpoint, the easiest way to control the output of the cooling coil is by means of the dry-bulb temperature of the conditioned space. This means then that the final dew point will vary somewhat depending on entering air conditions.

Summarizing then, the air washers permit close control over both final dry-bulb and final dew point temperatures, while the surface coolers permit close control over the final dry-bulb only.



Chapter 25

# SPRAY EQUIPMENT FOR HUMIDIFICATION AND DEHUMIDIFICATION

**Air Washers, Apparatus for Direct Humidification, Spray Generation and Distribution, Self-contained Humidifiers, Atmospheric Water Cooling Equipment, Design Wet-bulb Temperatures, Cooling Ponds, Spray Cooling Towers, Natural Draft Deck Type Towers, Mechanical Draft Towers, Winter Freezing**

AIR humidification is effected by the vaporization of water which always requires heat from some source. This heat may be added to the water prior to the time vaporization occurs or it may be secured by a transformation of sensible heat of the air being humidified to latent heat as the vapor is added to the air. The thermodynamics of the process are discussed in Chapter 1. Dehumidification consists of the removal of moisture from air and may or may not involve the removal of heat from the air-vapor mixture. With spray equipment dehumidification of air necessitates the removal of heat.

## AIR WASHERS

Air washers may be used as either humidifiers or dehumidifiers depending upon the method of their operation and the temperature of the spray water. The functions of an air washer are to regulate the moisture and heat content of air passing through it and to remove dust and dirt from the air. As cleaning devices air washers are not as effective as air filters in the removal of dust and dirt.

The construction of commercial air washers is indicated in Figs. 1 and 2. Any air washer consists essentially of a chamber through which the air passes and comes in intimate contact with water. This chamber may be built of either wood, stone, or sheet metal; the latter being the almost universal material of construction. The lower portion of the washer chamber serves as a sump for the water passing to its bottom.

Contact between the air and the washer water is secured: (1) by breaking the water into a very fine mist, (2) by passing the air over surfaces which are continuously wetted by water, or (3) by a combination of water sprays and wetted plates. Scrubber-plate types of washers are